

Atkinson has suggested that the influence of the macro-symbiont upon the tubercle organism may have much to do with the variability of form as seen in the different types of bacteroids.

Bearing upon this question of variety of species are the very interesting observations of Bolley<sup>26</sup> on the natural distribution of tubercles on the roots of indigenous and introduced legumes of the western plains. The native flora of the region is distinctively leguminous and he gives a list of native forms that he finds well provided with tubercles under natural conditions of environment. Many of the introduced legumes, especially *Trifolium pratense* often fail to establish themselves in the Dakotas for some reason. On stray plants, self-seeded and alone, he finds few, if any, tubercles, even though they may be growing in the midst of the native leguminous forms, but when preceded by *T. repens* this form develops nodules on its roots and is apparently thrifty. Several other introduced legumes fail to produce tubercles when planted on the virgin soil.

The inability of these species to produce nodular outgrowths would seem to favor the theory that their special organism was lacking and therefore would indicate that there is a variety of species. These observations have, however, only a circumstantial value in lieu of actual infection experiments.—  
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### The influence of traction upon the growth of plants.

Hegler in a recent paper<sup>1</sup> points out some of the work done on this subject by other investigators: (1). Baranetzky concluded that the duration and intensity of growth were in no wise affected by traction. (2). Max Scholtz thought that the effect of traction was twofold: (a) a retardation which he considered a pathological effect; (b) an acceleration in which he saw the real mechanical effect of the traction. The author advances some important objections to these conclusions and then gives an account of his own investigations.

*Method.*—Two plants were used, one with and one without a weight. Measurements were taken by means of distance marks, microscope and micrometer, or by the Bara-

<sup>26</sup> Ag. Science 7: 58. 1893.

<sup>1</sup> HEGLER, ROBERT. Ueber den Einfluss des mechanischen Zugs auf das Wachsthum der Pflanze. Beiträge zur Biologie der Pflanzen, 6: 281. 1894.



netzky registering auxanometer. The curves of both plants were plotted together for comparison. Shoots, petioles and seedlings of the following plants were used. *Helianthus annuus*, *Helianthus tuberosus*, *Phaseolus multiflorus*, *Tropaeolum majus*, *Tropaeolum minus*, *Ricinus bipinnatus*, *Linum usitatissimum*, *Cannabis sativa*, and *Dahlia variabilis*.

I. By a series of experiments, using weights of 20–150<sup>gm</sup> the conclusion is reached that the retardation of growth is to be regarded as a typical irritation phenomenon. An acceleration of growth takes place as soon as the weight ceases to act as a stimulus; but a new retardation can be produced by upsetting the equilibrium by an increase in weight.

II. The amount of weight necessary to produce a retardation varies in the same individual. Weights of 1.3–5<sup>gm</sup> are sufficient to call forth a response in some plants, but others require still larger weights.

III. The retardation produced by traction is the greatest at the beginning of the grand period, diminishes towards the maximum, where it is almost nothing, and again increases as we descend the other arm of the curve. Large weights (150<sup>gm</sup>) call forth a retardation even at the maximum of the grand period.

IV. The same is true for the daily period. If the irritability at the daily maximum is very low, the weight which before called forth a retardation, here produces an acceleration of growth. When a weight which has upset the equilibrium remains constant, the change of stimulus gradually ceases to work and to give place to the mechanical effect. A diminution in the weight also produces a retardation. The retardation then is dependent upon the abrupt change of weights, either an increase or a decrease.

V. By using etiolated specimens, the daily periodicity was avoided, when the retardation was not inhibited at certain phases but remained regular. The etiolated specimens were very sensitive to the weight as a stimulus.

VI. The approximate proportion given by Scholtz between the acceleration and the number of days is an inverse proportion between the weight and the amount of acceleration. For the same number of days the acceleration decreases with the increase of weight and passes with the high weight in the second to fourth day to a retardation of growth.

VII. A new retardation may be produced by a spontane-



ous increase of the sensitiveness to the stimulus; if it continues to increase, an inhibition of the growth in length must result.

VIII. The retardation is not produced by a depression of the hydrostatic pressure. The comparison of the turgor of cells from plants provided with weights and plants without weights showed a higher pressure in the plants subjected to traction. A similar retardation and increase in turgor was produced by gypsum jackets. In roots, especially, the pressure reached a considerable height and is perhaps of considerable biological importance. The investigations of Eschenhagen, Wortmann, and Zacharias are also analogous and showed with increase in turgidity, a retardation or inhibition similar to that produced by traction.—F. D. HEALD, *University of Wisconsin.*